SMART CONNECTION MANAGEMENT OF PORTABLE DEVICES

The present invention generally relates to network communication systems, and more particularly, to systems and methods for providing smart connection management of portable devices within a network communication system based, for example, on customizable connection profiles.

The recent proliferation of a wide variety of different wired and wireless access technologies, such as Ethernet, WWAN, WLAN, Wi-Fi, Bluetooth and GPRS, has made it possible for portable devices to be connected to the Internet at virtually any time and from virtually any location. Although seamless roaming across heterogeneous networks is still uncommon, the increased availability of combo-products, such as 802.11a/b, WLAN/GPRS and WLAN/Bluetooth cards, has enabled portable devices to select from among multiple available network connections. Because these network connections have different advantages and disadvantages in terms of access fees, bandwidth, signal quality, power consumption, etc., there is a need for the portable device to be "always best connected" to the Internet using the connection having the most desirable combination of connection characteristics.

The problem is that the process of setting up connections is mostly manual and requires complex procedures to be performed by the end user. Because the end user often lacks the necessary technical expertise, the end user is often unable to take full advantage of the connections available to the portable device and/or select the connection that provides the "best" connection in accordance with the user's preferences. IT managers and ISP providers also experience problems enforcing consistent communication policies across a group of users due to this largely manual connection set up process. For example, it is often difficult or impossible to implement policies that cause each user's portable device to automatically select the network connection having the lowest cost, highest security, or lowest strain on network resources. As a result, these problems provide either a sub-optimal user experience or undesirable selections among the available network connections.

Existing approaches have attempted to alleviate these problems by providing mechanisms to automate the connection selection process. These automation mechanisms, however, typically utilize a fixed selection logic that selects among connections based solely on connection availability. For example, these mechanisms may configure the portable device to switch to a secondary connection (e.g., Bluetooth) only if the default connection (e.g., WLAN) is unavailable. This fixed and overly simplistic approach

typically fails to take into consideration the actual preferences of the individual user or IT manager. In this context, the user may actually prefer to use a different default connection at a particular location or at certain times of the day and/or switch to a secondary connection in response to access fees exceeding a certain limit or the remaining battery capacity of the portable device falling below a certain threshold.

Furthermore, if the portable device switches from one connection to another during a communication session, these existing approaches often require the user to authenticate the new connection by, for example, providing a user name and password or executing one or more connection authentication applications. If the portable device switches to a different network (e.g., from private WLAN network to a public GPRS cellular network), the user may also be required to manually input special configuration parameters or execute one or more applications in order to negotiate a new IP tunneling scheme between the portable device and the intended destination. These processes can interrupt the user's on-going communication session, resulting in a less than optimal solution.

Therefore, in light of the deficiencies of existing approaches, there is a need for systems and methods for providing smart connection management of portable devices. These systems and methods would preferably take into consideration the user's preferences and/or company-wide communication policies.

Embodiments of the present invention alleviate many of the foregoing problems by providing systems and methods for smart connection management of portable devices. In one embodiment, a portable device that is configured to support a plurality of different network connection types, such as Ethernet, WWAN, WLAN, Wi-Fi, Bluetooth and GPRS, stores a user configurable connection profile in order to manage the plurality of network connection types and automatically select among them in accordance with user preferences. The profile may be configured to store configuration parameters for each of the plurality of network connection types and user definable selection criteria for selecting between the plurality of network connection types. When the portable device is activated or is roaming within the communication network, a connection detector within the portable device detects network connections that are available to the portable device. A connection manager, coupled to the profile and the connection detector, then selects a particular one of the plurality of network connections based on the user definable selection criteria and the connection type of each of the detected network connections, and activates the selected

network connection using the stored configuration parameters associated with the network connection type of the selected network connection.

The configuration parameters stored within each profile may comprise various network settings and user preferences for each network connection type, such as the network address of the portable device, the default mode for the connection type, device name of the portable device for a the connection type, etc. The configuration parameters may also include parameters for automatically controlling connection authentication, such as user name and password, and parameters for automatically performing IP tunneling negotiation in accordance with a user selected tunneling negotiation scheme so that the portable device can automatically authenticate and establish new connections of a different connection type or with a different network during the same communication session. The configuration parameters may also reference one or more software applications for performing connection configuration, connection authentication or IP tunneling negotiation that are to be automatically executed by portable device in response to connection activation, thereby avoiding the need for user intervention.

The user definable selection criteria may comprise rules or parameters that define the user's preferences in selecting between connection types. These parameters may include, for example, a day of week parameter, time of day parameter, location parameter, link quality threshold parameter, access fee limit parameter, time of use limit parameter, an available battery capacity parameter or combinations of the foregoing. These selection criteria parameters enable the portable device to select, for example, one type of connection when the user is at home, a second type of connection when the user is at the office and the remaining batter capacity of the portable device exceeds a predetermined threshold, and a third type of connection if the user/company imposed access fee limits or access time limits are exceeded. The selection criteria may also include rules or parameters for selecting between different connection configurations having the same connection type. For example, the selection criteria may comprise rules for selecting between a plurality of GPRS connection configurations based, for example, on applicable access fee charges, the identity of the carrier, or one or more of the other parameters mentioned above.

Preferably, the profile (and the associated configuration parameters and connection selection criteria) would be downloaded to the portable device from a remote server or remote profile database so as to reduce or avoid the need for manual configuration. If desired, the user could fine-tune the downloaded profile using a relatively simple

configuration tool. Allowing (or requiring) profiles to be downloaded to the portable device and/or restricting user modification of selected configuration parameters or selection criteria allows companies to maintain some level of control over its user base and implement company-wide communication policies. For example, updated profiles could be periodically pushed to the portable device in response to changes in the company's communication policy, thereby causing the portable device to use different configuration parameters or different selection criteria.

In another embodiment, the connection manager may be further configured to monitor the status of the plurality network connection and/or the portable device to determine whether the selected network connection continues to satisfy the selection criteria. For example, the connection manager may be configured to monitor a link quality of the selected network connection, cumulative access fees associated with the selected network connection, an amount of time that the selected network connection has been activated, a location of the portable device, or a remaining battery capacity of the portable device. If the selected network connection ceases to satisfy the selection criteria, the connection manager may be configured to deactivate the selected network connection, and activate a second one of the remaining available network connections based on the user definable selection criteria and the connection type of each of the remaining available network connections. Furthermore, in order to avoid problems associated with interrupting an on-going communication session, the connection manager may be further configured to perform automatic tunnel negotiation and connection authentication in accordance with the configuration parameters stored in the profile.

By providing customizable profiles that may be downloaded from a remote server or remote profile database and mechanisms for automatic connection authentication and tunneling negotiation, embodiments of the present invention enable portable devices to automatically select the "best" available connection in accordance with user preferences or company communication policies and reduce or avoid the problems associated with switching between different connection types or different networks during a communication session.

These and other features and advantage of the present invention will become more apparent to those skilled in the art from the following detailed description in conjunction with the appended drawings in which:

Figure 1 illustrates a block diagram of an exemplary system in which the principles of the present invention may be advantageously practiced;

Figure 2 illustrates an exemplary functional block diagram of a portable device that may be used in accordance with embodiments of the present invention; and

Figure 3 illustrates an exemplary method in flowchart form for performing smart connection management of a portable device in accordance with embodiments of the present invention.

Embodiments of the present invention provide systems and methods for smart connection management of portable devices. The following description is presented to enable a person skilled in the art to make and use the invention. Descriptions of specific applications are provided only as examples. Various modifications, substitutions and variations of the preferred embodiment will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments and applications without departing from the scope of the invention. Thus, the present invention is not intended to be limited to the described and illustrated embodiments, and should be accorded the widest scope consistent with the principles and features disclosed herein.

Referring to Figure 1, a block diagram of an exemplary system in which the principles of the present invention may be advantageously practiced is illustrated generally at 100. As illustrated, the exemplary system includes a portable device 110, such as a PDA, notebook computer or portable Internet appliance, that is configured to connect to services on the Internet 130 via a variety of network connections types, such as Ethernet, WWAN, WLAN, Wi-Fi, Bluetooth and GPRS. In order to manage these different connection types and automatically select the "best" available network connection in accordance with user preferences, embodiments of the present invention incorporate a customizable profile (illustrated in Figure 2) within the portable device 110. This profile may be configured as an XML file that stores configuration parameters for configuring network connections and user definable selection criteria for selecting between available network connections.

The configuration parameters within the profile may include information regarding network settings for each network connection type, such as the network address of the portable device 110, the default mode for the connection type, device name of the portable device 110, etc. In other embodiments, the configuration parameters may also include parameters for automatically controlling connection authentication, such as user name and password, which may be useful in reducing user intervention with respect to connection

activation. Additional advantages with respect to hand-off between different connections types or different networks may be achieved by further including configuration parameters within the profile for automatically performing IP tunneling negotiation through firewalls, such as firewalls 165a, 165b, in accordance with a user selected tunneling negotiation scheme, such as first attempting to use more efficient GRE, ESP or IP-in-IP tunneling and if unsuccessful, attempting to use less efficient, but more widely accepted HTTP tunneling. The configuration parameters may further include parameters that automatically cause the portable device 110 to execute one or more applications for performing connection configuration, connection authentication or IP tunneling negotiation in order to provide a seamless transition between different connection types or different networks.

The user definable selection criteria within each profile may comprise rules or parameters that enable the portable device 110 to select between available network connections in accordance with the preferences defined by the selection criteria. For example, these rules may provide preferences for one connection type over another based on the day of the week, time of day, location of the portable device 110, link quality of the available connections, billing information (e.g., time of day, traffic, $/unit, $limit, time limit), remaining battery capacity, or combinations of the foregoing. The selection criteria may also include rules or parameters for selecting between different connection configurations having the same connection type. For example, the selection criteria may comprise rules for selecting between a plurality of GPRS connection configurations based, for example, on applicable access fee charges, the identity of the carrier, or one or more of the other parameters mentioned above. It will be appreciated that the rules and parameters mentioned above are provided only as examples and that additional rules and parameters could be used to define the selection criteria in accordance with embodiments of the present invention.

In order to reduce or avoid the need to manually configure the profile (and the associated configuration parameters and connection selection criteria) within the portable device 110, embodiments of the present invention provide a profile database 170 located at a remote server, such as mobility server 160 or a web server connected to the Internet 130. Preferably, the portable device 110 would include software (e.g., on an installation disk) that would enable the portable device 110 to automatically connect to a predetermined remote server through a default connection so that the user can browse the available profiles within the profile database 170. The user can then download a selected profile to the

portable device 110. If desired, the user can fine-tune the downloaded profile using a relatively simple configuration tool. Allowing (or requiring) profiles to be downloaded to the portable device 110 and/or restricting user modification of selected configuration parameters or selection criteria allows companies to maintain some level of control over its user base and implement company-wide communication policies. For example, updated profiles could also be periodically pushed to the portable device 110 in response to changes in the company's communication policy. These aspects of the present invention enable companies to implement and enforce policies that would cause each user's portable device 110 to automatically select the network connection having the lowest cost, highest security, lowest strain on network resources, etc.

Once the portable device 110 selects a connection based on the information contained in the profile, the portable device 110 may also be configured to monitor the status of all available connections and/or the portable device to determine whether the selected connection continues to satisfy the selection criteria. For example, the portable device 110 may be configured to monitor a link quality of the selected connection, cumulative access fees associated with the selected network connection, an amount of time that the selected network connection has been activated, a location of the portable device, or a remaining battery capacity of the portable device. If the selected connection ceases to satisfy the selection criteria, the portable device 110 may be configured to use the profile to deactivate the selected connection, and activate one of the remaining available connections. Furthermore, in order to avoid problems associated with interrupting an on-going communication session, the portable device 110 may be further configured to perform automatic tunnel negotiation and connection authentication in accordance with the configuration parameters stored in the profile.

In the embodiment of Figure 1, for example, the profile associated with portable device 110 may include configuration parameters and selection criteria that cause the portable device 110 to automatically select and configure a higher bandwidth WLAN connection with WLAN access point 180 (in lieu of a lower power Bluetooth connection with Bluetooth access point 185), if the portable device 110 is located within the user's corporate network 120 and the remaining battery capacity of the portable device exceeds a predetermined threshold. If the portable device 110 moves outside the corporate network 110 and the link quality of the WLAN connection falls below a predetermined threshold, the portable device 110 would use the profile to automatically deactivate the WLAN

connection and activate a Bluetooth connection with the user's Bluetooth-enabled mobile phone 115 so that the portable device 110 can remain connected to the Internet 130 via the mobile phone 115, GPRS network 140 and cellular base station 190. If the portable device 110 enters the user's home network or a network hotspot 150, the portable device 110 may again use the profile to automatically deactivate the more expensive Bluetooth connection with mobile phone 115 and activate a less expensive, higher bandwidth Wi-Fi connection with the Wi-Fi access point 195. Because the portable device 110 automatically selects and configures available connections based on the user definable selection criteria and configuration parameters stored in the connection profile, the portable device 110 can be configured to always use the best available connection in accordance with the user's preferences.

Referring to Figure 2, an exemplary functional block diagram of a portable device that may be used in accordance with embodiments of the present invention is illustrated generally at 200. As illustrated, the exemplary portable device includes one or more applications 210 that connect to services on the Internet through a network control layer 220 and a data link control layer 230. The exemplary portable device also includes a connection manager 240 that is responsible for scanning available network connections, activating the best available connection based on configuration parameters 243 and selection criteria 247 stored with a connection profile 245, and coordinating connection control with the network control layer 220 and the data link control layer 230.

A configuration tool 260 coupled to the connection manager 240 may be used to allow the user to create the profile 260 using, for example, a graphical user interface with a profile wizard that would enable the user to easily enter the necessary information. Alternatively, an initial profile 240 could be downloaded from a remote server that stores a profile database, and the configuration tool 260 could be used to fine-tune all or a permitted subset of the configuration parameters 243 and selection criteria 247 (e.g., in the event that an IT manager desires to restrict some of the profile information that can be changed by the user). In any event, the profile 245 could be stored as an XML file such that the configuration tool 260 would be configured to modify the profile 245 by making changes to the XML file.

It should be noted that the profile 245 can be used to store configuration parameters 243 and selection criteria 247 for different connection types and different configurations of the same connection type. For example, the profile 245 may store configuration parameters

and rules for selecting between a plurality of different GPRS configurations based, for example, on applicable access fee charges, the identity of the carrier, etc. An exemplary profile 245 in accordance with this embodiment of the present invention is set forth below:

```
<?xml version="1.0" ?>
- <MobileNode version="0.1" homeTEPname="217.56.92.82"
    activeProfile="2">
  - <profile TEPName="mobile.monza.research.philips.com"
    profileName="Philips Research Monza">
    <wlan essid="prm_wip_1" wepKey="t21c9"
      hardware="PCMCIA" mode="Managed" />
  - <cellular serialDevice="/dev/modem" hardware="PCMCIA-
      serial" standard="GPRS" useOperator="1">
    - <!--
    Cellular operator specific parameters
      -->
      <operator name="tim"
        gprsScriptFilename="gprs_tim.chat"
        gsmScriptFilename="gsm_tim.chat" />
    </cellular>
  - <bluetooth noAps="2" hardware="CF"
      deviceName="/dev/bt0">
      <ap name="Possio PX-20"
        MACAddress="00:05:4e:00:1e:8f" type="LAP"
        backbone="WLAN" key="" />
      <ap name="T68" MACAddress="" type="DUN"
        backbone="cellular" key="" />
    </bluetooth>
    <ethernet cachedIPSubnet="10.138.129.0" />
  </profile>
  ---
- <profile TEPName="mobile.psvc.philips.com" profileName="US
    PSVC">
    <wlan essid="MNODE" wepKey="monza" hardware="PCMCIA"
      mode="Managed" />
  - <cellular serialDevice="/dev/modem" hardware="PCMCIA-
      serial" standard="GSM" useOperator="1">
```

```
- <!--
we use the T68 phone here with standard serial cable connection
  -->
  <operator name="cingular"
    gprsScriptFilename="gprs_tim.chat"
    gsmScriptFilename="gsm_usa.chat" />
  <operator name="voice stream" gprsScriptFilename=""
    gsmScriptFilename="gsm_voicestream.chat" />
 </cellular>
- <bluetooth noAps="1" hardware="CF"
    deviceName="/dev/bt0">
  <ap name="T68" MACAddress="" type="DUN"
    backbone="cellular" key="" />
 </bluetooth>
 <ethernet cachedIPsubnet="" />
</profile>
---
- <profile TEPName="mobile.psvc.philips.com"
    profileName="Starbucks">
  <wlan essid="tmobile" wepKey="off" hardware="PCMCIA"
    mode="Managed" />
- <cellular serialDevice="/dev/modem" hardware="PCMCIA-
    serial" standard="GSM" useOperator="1">
  - <!--
  we use the T68 phone here with standard serial cable connection
    -->
    <operator name="cingular"
      gprsScriptFilename="gprs_tim.chat"
      gsmScriptFilename="gsm_usa.chat" />
    <operator name="voice stream" gprsScriptFilename=""
      gsmScriptFilename="gsm_voicestream.chat" />
  </cellular>
- <bluetooth noAps="1" hardware="CF"
    deviceName="/dev/bt0">
    <ap name="T68" MACAddress="" type="DUN"
      backbone="cellular" key="" />
  </bluetooth>
```

```
    <ethernet cachedIPsubnet="" />
  </profile>
</MobileNode>
```

With respect to the data link control layer 230, the primary functions of this layer 230 are performed by the wireless adaptation layer 235 under the direction of the connection manager 240. The wireless adaptation layer 235 is preferably a software module that controls network drivers 270 (e.g., Ethernet, WLAN, Bluetooth, Wi-Fi or PPP links like those running on GPRS or PSTN modems) and provides a uniform API to the connection manager 240 for common radio functions. Under the control of the connection manager 240, the wireless adaptation layer 235 can switch between network drivers 270 and can control the mapping of the tunneling interface 237 exposed to the application 210, thereby enabling the network driver 270 to be dynamically changed without adversely affecting the application 210.

With respect to the network control layer 220, the connection manager 240 interfaces with a routing manager 223 whenever the connection manager 240 decides to switches between two different networks. In this context, when the connection manager 240 switches to a different network (thereby requiring a change to the IP address associated with the new network), the connection manager 240 causes the routing manager 223 to negotiate IP tunneling in accordance with the configuration parameters 243 stored in the profile 245. Furthermore, if the portable device attempts to access an Intranet, such as the corporate network illustrated in Figure 1, then the connection manager 240 may also initiate a VPN client 227 within the network control layer 220 and provide configuration parameters 243, such as user name and password, so that the VPN client 227 can proceed with authenticating the user without requiring user intervention. This aspect of the present invention enables the portable device to seamlessly roam across heterogeneous networks without interrupting the user's communication session.

In operation, when the portable device is activated, the connection manager 240 scans the available network interfaces 270 to search for available network connections. If only one network connection is found, the connection manager 240 uses its stored profile to activate the detected connection using the network configuration information associated with the connection type of the available network connection. If more than one available network connection is found, on the other hand, the connection manager 240 uses the selection criteria 247 and other information associated with the connection type of each

available connection in order to select the best available connection. Once a selection has been made, the connection manager 240 communicates this information to the wireless adaptation layer 235 which switches data flow to the appropriate network driver 270. The connection manager 240 may also output status information, such as the current network, network settings, or available bandwidth, to a visualization tool 250 that displays the status information to the user.

After the connection manager 240 selects an available connection, the connection manager 240 monitors all available connections to determine whether the selected connection continues to satisfy the selection criteria. If the status of the selected connection deteriorates, or if a better connection become available, then the connection manager 240 would communication the newly selected connection to the wireless adaptation layer 235 and, if necessary, the routing manager 223 and VPN client 227. The wireless adaptation layer 235 would then switch to the network driver 270 associated with the newly selected connection, set the network driver setting using the configuration parameters 243 and, if necessary, coordinate with the tunneling interface 237 to update the mapping of IP addresses, thereby providing a seamless transition between network connections of a different connection type and ensuring that the portable device is "always best connected" in accordance with the user definable selection criteria.

Referring to Figure 3, an exemplary method in flowchart form for performing smart connection management of a portable device in accordance with embodiments of the present invention is illustrated generally at 300. As illustrated, when the portable device is switched on, the exemplary method proceeds to step 310 where the portable device searches for available network connections. If no available network connections are found at step 320, the exemplary method proceeds back to step 310 where the portable device performs another search for available network connections. If one or more available network connections are found at step 320, the exemplary method proceeds to step 330, where the portable device determines whether any of available network connections matches any of the connection types stored in the connection profile.

If one or more of the available network connections do not match any of the connection types, the exemplary method proceeds to step 335, where the user is prompted to select one of the available network connections and provide any necessary configuration parameters. Once the user enters the requested information, the exemplary method then uses this information to update the configuration parameters and selection criteria for the

connection profile so that the portable device will automatically make the same selection and use the same configuration parameters when presented with the same context in the future. The exemplary method then proceeds to step 350, where the selected connection is activated using the configuration parameters associated with the connection type of the selected connection.

Referring back to step 330, if all the available connections match a connection type stored in the connection profile, the exemplary method proceeds to step 330, where the portable device selects one of the available network connections based on the selection criteria and the connection type of each of the available network connections. The exemplary method then proceeds to step 350, where the selected connection is activated using the configuration parameters associated with the connection type of the selected connection.

Once the selected connection is activated at step 350, the exemplary method proceeds to step 360, where the portable device monitors the status of the available network connections to determine whether the selected connection continues to satisfy the selection criteria. If the selected network connection ceases to satisfy the selection criteria, the exemplary method proceeds to back to step 310 so that the portable device can re-perform the exemplary method, deactivate the selected network connection and activate a new network connection as described above. Alternatively, the exemplary method could proceed to from step 360 to step 370, where the portable device deactivates the selected network connection, and activates one of the remaining available network connections based on the selection criteria and the connection type of each of the remaining network connections.

While the present invention has been described with reference to exemplary embodiments, it will be readily apparent to those skilled in the art that the invention is not limited to the disclosed and illustrated embodiments but, on the contrary, is intended to cover numerous other modifications, substitutions and variations and broad equivalent arrangements that are included within the scope of the following claims.